# A NEW SPECIES OF SCLERACTINIAN CORAL (CNIDARIA, ANTHOZOA), *MADRACIS CARMABI* N. SP. FROM THE CARIBBEAN

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ABSTRACT

*Madracis carmabi,* n. sp. is a relatively common zooxanthellate scleractinian coral found throughout the Caribbean. The species is described based on colonies collected from Curaçao. Features that distinguish this species from other *Madracis* species are the combination of (1) a branching morphology, and (2) decameral septal organization. The species is mostly found between 20–40 m depth. Hybridization between *Madracis decactis* and *Madracis formosa* is proposed as a process leading to this new species following the principles of reticulate evolution.

The scleractinian coral genus *Madracis* (Milne Edwards and Haime, 1849) is widespread in tropical waters from the western Indian Ocean and the Red Sea to the Eastern Pacific, and from the tropical western to eastern North Atlantic where the genus occurs in the sub-tropical Mediterranean (Zibrowius, 1980; Wells, 1983; Leao et al., 1988; Veron, 1995; Carpenter et al., 1997; Veron, 2000). Currently, nine species are described worldwide (Wells, 1973a,b; Veron and Pichon, 1976; Nishihira and Veron, 1995) and approximately four fossil species are recognized (Veron, 1995). Presently, seven species are restricted to the Caribbean where the genus has been present since the Eocene, although most species appear in the fossil record only since the Pleistocene (Swedberg, 1994). The species status of some *Madracis* species is currently debated (Zlatarski and Estalella, 1982; Fenner 1993; Diekmann et al., 2001). Large morphological plasticity and overlapping morphometric characters are mainly responsible for the vague species boundaries.

In our study on the evolutionary ecology of the Caribbean members of the genus *Madracis*, we first encountered the new species while surveying the south coast of Curaçao, Netherlands Antilles (12º05′N, 69º00′W) in 1997. The species is easily identifiable based on a combination of over-all colony morphology and the number of septs and has been observed at locations throughout the Caribbean basin: Saba, Aruba, Bonaire, Curaçao, Haiti, Panama, Cozumel, Dry Tortugas, and the Florida Keys. The new species shares characteristics with two other *Madracis* species; colony morphology and septal arrangement correspond to that of *M. formosa* and *M. decactis*, respectively. Close relationships and exchange of genetic information have been found for *Madracis* species (Diekmann et al., 2001), suggesting that species formation could currently take place in this genus following the principles of reticulate evolution (Veron, 1995). In such a case, traditional species concepts (Mayden, 1997) cannot be used for *Madracis.* Our purpose is to describe the new species for taxonomic purposes; therefore, we follow the morphological or phenetic species concept (Cronquist, 1988). In this paper we describe *M. carmabi* n. sp. from colonies we collected from the fringing reef of Curaçao, Netherlands Antilles, and provide additional information on its ecology.



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## Materials and Methods

Seven complete colonies of *M. carmabi* n. sp. were collected between 15 and 45 m depth in April 1999 and deposited in the Zoological Museum of the University of Amsterdam (ZMA), the Netherlands. For comparison, material of *M. decactis* and *M. formosa* from the same location was examined. Additional in situ examinations of *M. carmabi* n. sp. were made at various locations around Curaçao. All material was examined under a binocular dissecting photo-microscope under various magnifications. As a rule, at least 50 measurements using an ocular micrometer were made on random colonies and positions to describe skeletal structures. Polyp density was measured by overlying the colony with a flexible plastic sheet with a square centimeter grid. Ecological data were taken from other studies done at the same location. Distributional data were obtained from Vermeij and Bak (in press) and reproductive information from Vermeij et al., (2003), Vermeij et al. (in press).

Phylum *Cnidaria*
Subphylum *Anthozoa*
Class *Zoantharia*
Order *Scieractinia*
Family *Pocilloporidae*
Genus *Madracis* (Milne, Edwards and Haime 1849)
***Madracis carmabi*** new species

*Description*.—Colony consists of thick, compact, plocoid branches, brown in color with green-yellow stomodea (Fig. 1). Sometimes tentacles have a gray color at parts of the colony. It is easily identifiable underwater but shares characteristics with both *M. decactis* (decameral septal arrangement) and *M. formosa* (branching morphology). Branches are oval to round in cross section and bifurcate, but third order branches are seldomly found. Typical branching patterns are shown in Figure 2. Many branches are poorly developed, resulting in a bumped surface of the branches. Bifurcating branches often grow in one plane and often fuse. The mean distal branch width is 12.5 mm (SD = 3.1, n = 50) and branches are terminally blunt or lobed. Much of the basal part of the colonies is dead and overgrown with sponges, coralline algae, and polychaetes. Therefore, colonies mostly consist of a morphologically autonomous structure with living tissue on separate branches often not connected. On the underside of branches of deep water colonies (> 30 m) the polyps are spaced 1–3 diameters apart. Polyp density ranges between 12–35 po1yps per $cm^2$ and is on average 24.8 polyps $cm^{-2}$ (SD = 4.3; n = 56). Polyp diameter is on average 1.36 mm (SD = 0.26; n = 178) and ranges between 0.7 and 1.8 mm. Intra-colony variation in corallite morphology is large. Both corallites and septs are found sunken below the level of the coenosteum but also extending above it. The coenosteum in between the polyps is minutely granulose. The septa are predominantly decamerally arranged (Fig. 3) with occasionally a second set of ten, weakly developed secondary septa. All septa connect to the central columella, which sometimes lies sunken into the corallite. The species is zooxanthellate.

*Madracis carmabi* n. sp. has probably been referred to as *M. formosa* due to difficulties counting the number of septa in situ. For example the three colonies on page 15 (Vol. 2, in Veron, 2000), referred to as *M. formosa,* are likely to be *M. carmabi* n. sp. The colony

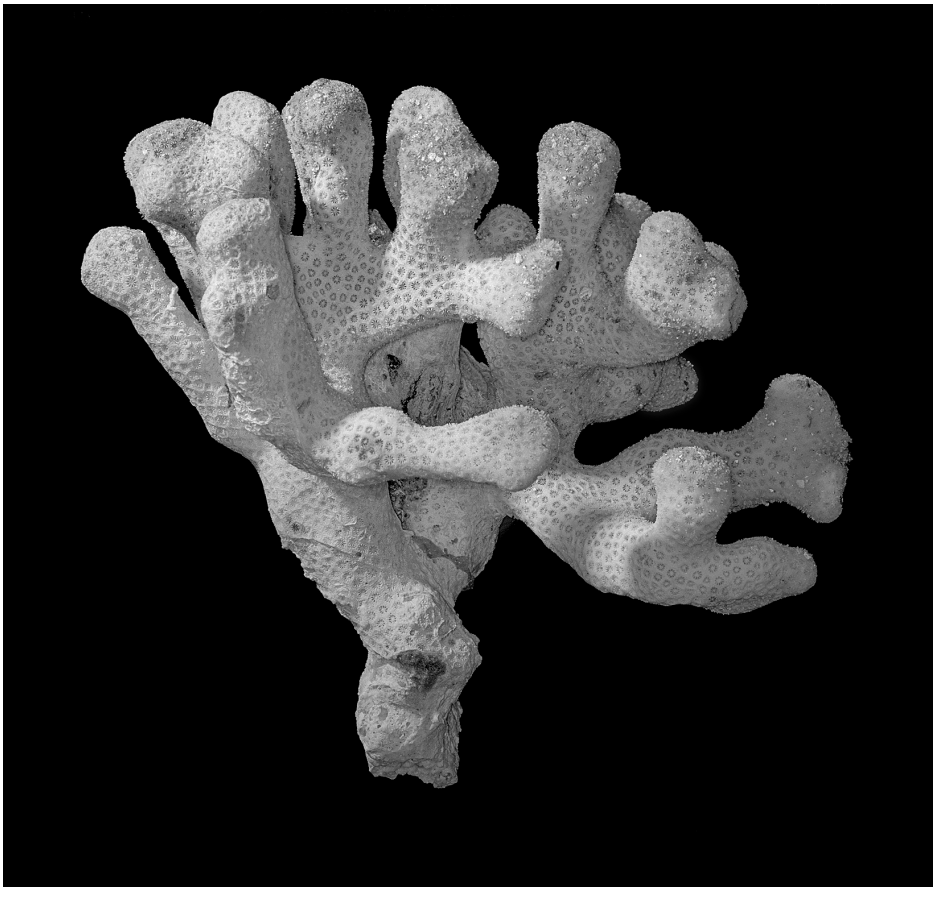

Figure 1. The holotype colony of *Madracis carmabi* n. sp. Zool. Museum University of Amsterdam no. COEL 08514. Collection: Buoy 2, Curaçao, N.A. Depth 15 m. 15 × 13 × 12 ( in cm; width × depth × height).

referred to as *M. formosa* in Humann (1992) is another example of confusion between the two species. Ten septa are clearly visible at his picture of *M. formosa*, which characterizes, together with the branching morphology, the colony as *M. carmabi* n. sp.

*Type Material*.—Holotype: *M. carmabi,* n. sp. ZMA no.COEL 08514. Curaçao, CARMABI Buoy 2, N.A. Depth 15 m. 15 × 13 × 12 (in cm; width × depth × height). Paratypes: ZMA no. COEL 08515. Depth 15 m. 13 × 9 × 21; ZMA no. COEL 08516. Depth 25 m. 13 × 11 × 21; ZMA no. COEL 08517. Depth 25 m. 13 × 9 × 17; ZMA no. COEL 08518. Depth 25 m. 13 × 10 × 14; ZMA no. COEL 08519. Depth 45 m. 16 × 13 × 17; ZMA no. COEL 08520. Depth 15 m. 30 × 13 × 26; ZMA no. COEL 08514. Depth 15 m. 15 × 13 × 12. All collections were made in April 1999 by M.J.A.V. at Buoy 2, Curaçao, Netherlands Antilles (12º7′47.96″N; 68º58′33.98″W).

*Etymology*.—We named this species in recognition of the supportive role of the CARMABI institute for more than 40 yrs of Caribbean coral reef research.

*Ecological Information*.—*Madracis carmabi* n. sp. occurs throughout the Caribbean and was observed in reefs surrounding Bonaire, Curaçao and Saba (Netherlands Antilles), Aruba, Navassa (Haiti), Panama, Cozumel (Mexico), and along the Florida Keys and Dry

Figure 2. Typical branching patterns of *Madracis carmabi* n. sp. photographed and redrawn from three colonies growing at 30 m at Buoy 2, Curaçao, Netherlands Antilles.

Tortugas (U.S.). All ecological information was collected at Curaçao, where *M. carmabi* n.sp has a limited bathymetric distribution. The largest colonies were generally found at > 20 m depths on the windward coasts of the islands and the largest colony found measured 6748 $cm^2$ (projected surface area; Playa Canoa, Curaçao 28 m). In Figure 4, the relative abundance of *M. carmabi* n. sp. is given together with two closely related *Madracis* species, *M. decactis* and *M. formosa,* from which the new species is assumed to have originated through hybridization (Diekmann et al., 2001). The distribution pattern suggests a classical hybrid zone (Futuyama, 1986), which corresponds to the data from Diekmann et al. (2001). It is not clear if hybridization is currently taking place, i.e., a zone of secondary contact (Margalef, 1974), or whether *M. carmabi* n. sp. inherited the intermediate depth preference from a combination of its supposed parental species, and

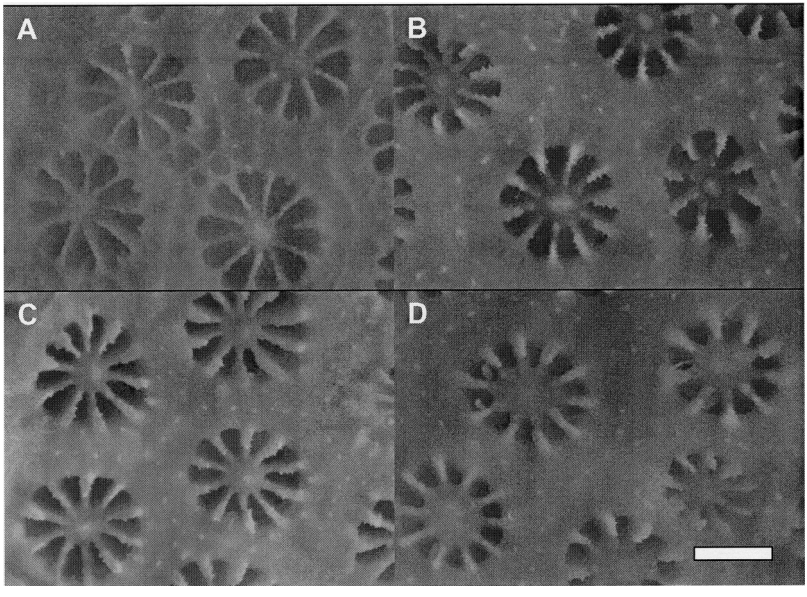


Figure 3. Corallite variation in *Madracis carmabi* n. sp. Scalebar indicates 1.0 mm. Colonies were collected by Diekmann et al. (2001) for a phylogenetic study. Samples are taken at the sides of four different colonies sampled at Curaçao. Note the variation in coenosteum structure (A vs. D), the variable number of septs (B), the presence of weakly developed secondary septs (A), and the variation in columella buildup (B vs D).

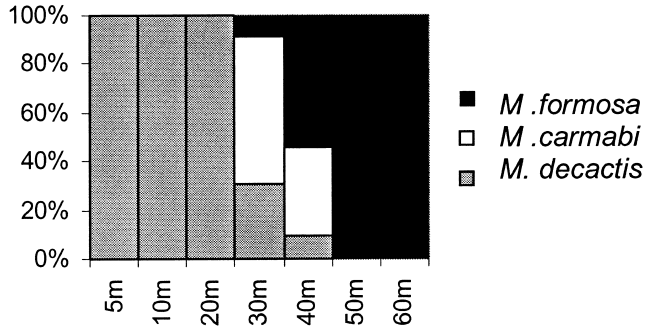


Figure 4. The relative abundance (%) of *M. carmabi* n. sp. over the entire reef slope (Carmabi, buoy one) together with two closely related *Madracis* species, *Madracis decactis* and *Madracis formosa,* from which the new species is believed to have originated through hybridization.

no genetic exchange is currently taking place. Genetic exchange is possible since reproductive isolation is absent between *Madracis* species (Vermeij et al., in press). All species, including *M. carmabi* n. sp. are simultaneously fertile from August until October and brood planulae (Vermeij et al., 2003, in press).

The study of hybridization processes in corals has only recently begun (Babcock, 1995; Richmond, 1995; Miller and Benzie, 1997; Willis et al., 1997; Hatta et al., 1999) and led to the idea that hybridization is more important in the evolution of corals than previously believed (Veron, 1995). Since coral genera containing many species are scarce in the Caribbean and field observations on hybrids are relatively rare, the genus *Madracis* can be a suitable subject to study the role of hybridization in coral evolution.

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